SECTION 13110A

CATHODIC PROTECTION SYSTEM (SACRIFICAL ANODE)

PART 1 GENERAL

1.1 DESCRIPTION

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNACTION (ASTM)
- ASTM B 843 (1993; R 2003) Magnesium Alloy Anodes for Cathodic Protection

NACE INTERNATIONAL (NACE)
- NACE RP0169 (2002) Control of External Corrosion of Underground or Submerged Metallic Piping Systems
- NACE RP0188 (1999) Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
- NFPA 70 (2002) National Electrical Code

UNDERWRITERS LABORATORIES (UL)
- UL 510 (1994; Rev thru Apr 1998) Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
- UL 514A (2004) Metallic Outlet Boxes

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with *Section 01330 SUBMITTAL PROCEDURES*:

A. SD-02 Shop Drawings

1. Drawings:

Six (6) copies of detail drawings consisting of a complete list of equipment and material including manufacturer's descriptive calculations including soil-resistivity, installation instructions and certified test data stating the maximum recommended anode current output density and the rate of gaseous production if any at that current density. Detail drawings shall contain complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will function properly as a unit.

2. Contractor's Modifications:

Six (6) copies of detail drawings showing proposed changes in location, scope of performance indicating any variations from, additions to, or clarifications of contract drawings. The drawings shall show proposed changes in anode arrangement, anode size and number, anode materials and layout details, conduit size, wire size, mounting details, wiring diagram, method for electrically-isolating each pipe, and any other pertinent information to proper installation and performance of the system.

B. SD-03 Product Data

1. Equipment:

Within 30 days after receipt of notice to proceed, an itemized list of equipment and materials including item number, quantity, and manufacturer of each item. The list shall be accompanied by a description of procedures for each type of testing and adjustments, including testing of coating for thickness and holidays. Installation of materials and equipment shall not commence until this submittal is approved.

2. Spare Parts:

Spare parts data for each different item of material and equipment specified, after approval of detail drawings and not later than six (6) months prior to the date of beneficial occupancy. The data shall include a complete list of parts, special tools, and supplies, with current unit prices and source of supply. One (1) spare anode of each type shall be furnished.

C. SD-06 Test Reports

1. Test and Measurements

Test reports in booklet from tabulating all field tests and measurements perform, upon completion and testing of the installed system and including final system test verifying protection, insulated joint and bond tests, and holiday coating test. A certified test report showing tat the connecting method has passed a 120-day laboratory test without failure at the place of connection, wherein the anode is subjected to maximum recommended current output while immersed in a three percent sodium chloride solution.

2. Contractor’s Modifications:

Final report regarding Contractor’s modifications. The report shall include pipe-to-soil potential measurements throughout the affected area, indicating that the modifications improved the overall conditions, and current measurements for anodes. The following special materials and information are required: taping materials and conductors; zinc grounding cell, installation and testing procedures, and equipment; coating material; system design calculations for anode number, life, and parameters to achieve protective potential; backfill shield material and installation details showing waterproofing; bonding and waterproofing details; insulated resistance wire; exothermic weld equipment and material.

D. SD-07 Certificates

1. Cathodic Protection System

Proof that the materials and equipment furnished under this section conform to the specified

requirements contained in the referenced standards or publications. The label or listing by the specified agency will be acceptable evidence of such compliance.

E. Services of "Corrosion Expert"

1. Evidence of qualifications of the "corrosion expert."

a. The "corrosion expert's" name and qualifications shall be certified in writing to the Contracting Officer prior to the start of construction.

b. Certification shall be submitted giving the name of the firm the number of years of experience, and a list of not less than five (5) of the firm's installation s three (3) or more years old that have been tested and found satisfactory.

F. SD-10 Operation and Maintenance Data

1. Cathodic Protection System

Before final acceptance of the cathode protection system, three(3) copies of operating manuals outlining the step-by-step procedures required for system startup, operation, adjustment of current flow, and shutdown. The manuals shall include the manufacturer's man, model number, service manual, parts list, and brief description of all equipment and their basic operation features. Three (3) copies of maintenance manual, listing routine maintenance procedures, recommendation for maintenance testing, possible breakdowns and repairs, and troubleshooting guides, the manuals shall include sing-line diagrams for the system as installed; instructions in making pip-to-reference cell potential measurements and frequency of monitoring; instructions for dielectric connections, sacrificial anode bonds; instructions shall include precautions to ensure safe conditions during repair of pipe or other metallic systems. The instructions shall be neatly bound between permanent covers and titled "Operating and Maintenance Instructions." These instructions shall be submitted for the Contracting Officer's approval. The instructions shall include the following:

a. As-built drawings, to scale of the entire system, showing the locations of the piping, location of all anodes and test stations, locations of all insulating joints, and locations of each structure-to-reference cell potentials as measured during the tests required by Paragraph: TEST AND MEASUREMENTS, of this section.

b. Recommendations for maintenance testing, including instructions in making pip-to-reference cell potential measurements and frequency of testing.

c. All maintenance and operating instructions and nameplate data shall be in English.

d. Instructions shall include precautions to insure safe conditions during repair of pipe system.

G. Training Course:

The proposed Training Course Curriculum (including topics and dates of discussion) indicating that all of the items contained in the operating and maintenance instructions, as well as demonstrations of routine maintenance operations, including testing procedures included in the maintenance instructions, are to be covered.

1.3 GENERAL REQUIREMENTS

The contractor shall furnish and install a complete, operating, sacrificial anode Cathodic protection system in complete compliance with NFPS 70, with all applicable Federal, State, and local regulations and with minimum requirements of this contract. The services required include planning, installation, adjusting and testing of a Cathodic protection system, using sacrificial anodes for Cathodic protection of the Fire Hydrants and their connectors. The Cathodic protection system shall include anodes, cables, connectors, corrosion protection test stations, and any other equipment required for a complete operating system providing the NACE criteria of protection as specified. Insulators are required whenever needed to insulate the pipes from any other structure. The Cathodic protection shall be provided on each fire hydrant.

1.3.1 Services of "Corrosion Expert"

The Contractor shall obtain the services of a "corrosion expert" to supervise, inspect, and test the installation and performance of the Cathodic protection system "Corrosion expert" refers to a person, who by thorough knowledge of the physical sciences and the principles of engineering and mathematics. Acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control of buried or submerged metallic surfaces. Such a person must be accredited or certified by the National Association of Corrosion Engineers (NACE) as a NACE Accredited Corrosion Specialist or an NACE certified Cathodic Protection (CP) Specialist or be a registered professional engineer who has certification of licensing that includes education and experience in corrosion control of buried or submerged metallic piping and tank systems, if such certification of licensing includes 5 years experience in corrosion control on underground metallic surfaces of the type under this contract. The "corrosion expert" shall make at least 3 visits to the project site. The first of these visits shall include acknowledging the type of pipeline coatings to be used and reporting to the Contractor type of cathodic protection required. Once the submittals are approved and the materials delivered, the "corrosion expert" shall revisit the site to ensure the Contractor understands installation practices and laying out the components. The third visit shall involve testing the installed cathodic protection systems and training applicable Base personnel or proper maintenance techniques. The "corrosion expert" shall supervise installation and perform all testing of all cathodic protection.

1.3.2 Contractor's Modifications

The specified system is based on a complete system with magnesium sacrificial anodes. The Contractor may modify the cathodic protection system after review of the project, site verification, and analysis, if the proposed modifications include the anodes specified and will provide better overall system performance. The modifications shall be fully described, shall be approved by the Contracting Officer or designated representative, and shall meet the following criteria. The proposed system shall achieve a minimum pipe-to-soil potential of minus 1000 millivolts with reference to a saturated copper-copper sulfate reference cell on the underground components of the piping or other metallic surface. This potential shall be obtained over 95 percent of the metallic area. The anode system shall be designed for a life of twenty-five (25) years of continuous operations.

1.3.3 Isolators

Isolators are required to insulate the newly installed piping from any other structure. Isolators shall be provided with lighting protection and a test station as shown.

1.3.4 Anode and Bond Wires

The anode weight and quantity for each fire hydrant is shown on the drawings that accompany this specification. For each cathodic system, the metallic components and structures to be protected shall be made electrically continuous. This shall be accomplished by installing bond wires between the various metallic structures.

1.3.5 Surge Protection - Not Used.

1.3.6 Summary of Services Required

The scope of services shall include, but shall not be limited to, the following:

a. Cathodic Protection Systems
b. System testing
c. Training
d. Operating and maintenance manual
e. Insulator testing and bonding testing
f. Coating and holiday testing shall be submitted within 45 days of notice to proceed

1.3.7 Nonmetallic Pipe System - Not Used

1.3.7.1 Coatings

Coatings for metallic components shall be as required for metallic fittings. Protective covering (coating and taping) shall be completed and tested on each metallic component *such as valves, hydrants and fillings). This covering shall be as required for underground metallic pipe. Each test shall be witnessed by the Contracting Officer. Coatings shall be selected, applied, and inspected in accordance with NACE RP0190 and as specified in these specifications. The use of nonmetallic pipe does not change other requirements of the specifications. Any deviations due to the use of nonmetallic pipe shall be submitted for approval. Each fire hydrant and valve shall have two (2) coats of epoxy, 5 mil per coat, for a total dry film thickness of 10 mils in accordance with the coatings manufacturer’s recommendations.

1.3.7.2 Tracer Wire

When a nonmetallic pipe line is used to extend or add to an existing metallic line, an insulated No. 8 AWG copper wire shall be thermit-welded to the existing metallic line and run the length of the new nonmetallic line. This wire s hall be used as a locator tracer wire and to maintain continuity to any future extensions of the pipe line.

1.3.8 Tests of Components

A minimum of four (4) tests shall be made at each metallic component in the piping system. Two (2) measurements shall be made directly over the anodes and the other two (2) tests shall be over each of the components, but at the farthest point from the anodes. Structure and pipes shall be shown with the cathodic protection equipment. All components of the cathodic protection system shall be shown on drawings, showing their relationship to the protected structure or component. A narrative shall describe how the cathodic protection system will work and provide testing at each component. Components requiring cathodic protection shall include but not be limited to the following:

a. Shutoff valves.
b. Each connector or change-of-direction device.
c. Any metallic pipe component or section
d. Each fire hydrant

1.3.9 Drawings

Detailed drawings shall be provided showing location of anodes, insulated fittings, test stations, and bonding. Locations shall be referenced to two (2) permanent facilities or mark points.

1.3.10 Electrical Potential Measurements

All potential tests shall be made at a minimum of 10 foot intervals witnessed by the Contracting Officer. Submittals shall identify test locations on separate drawings, showing all metal to be protected and all cathodic protection equipment. Test points equipment and protected metal shall be easily distinguished and identified.

1.3.11 Achievement of Criteria for Protection

All conductors, unless otherwise shown, shall be routed to or through the test stations. Each system provided shall achieve a minimum pipe-to-soil potential of minus 1000 millivolts potentials with reference to a saturated copper-copper-sulfate reference cell on all underground components of the piping. This potential should be obtained over 95 percent of the metallic area. Testing will be witnessed by the Contracting Officer. Additional anodes shall be provided by the Contractor if required to achieve the minus 1000 millivolts. Although acceptance criteria of the cathodic protection systems are defined in NACE RP0169, for this project the potential of minus 1000 millivolts is the only acceptable criteria.

1.3.12 Metallic Components and Typicals

a. Fire Hydrants: Fire hydrant pipe components shall have a minimum of one (1) anodes. This number of anodes is required to achieve minus 1000 millivolts potential on the metallic area. As a minimum, the magnesium anode unpackaged weight shall be 17 pounds. The magnesium anodes shall be located as shown on the drawings and routed through a test station.

b. Valves: Each valve shall be protected with one (1) magnesium anode. The number and size shall be as shown on the drawings.

1.3.13 Metallic Component Coating

Coatings for metallic components shall be as required for metallic fittings as indicated. This will include fire hydrants, T's, elbows, valves, etc. Coatings shall be selected, applied, and inspected in accordance with NACE RP0190 and as specified in these specifications.

PART 2 PRODUCTS

2.1 MAGNESIUM ANODES

2.1.1 Anode Composition

Anodes shall be of high-potential magnesium alloy, made of primary magnesium obtained from sea water or brine, and not made from scrap metal. Magnesium anodes shall conform to ASTM B 843 and to the following analysis (in percents) otherwise indicated:

Aluminum, max.	0.010
Manganese, max.	0.50 to 1.30
Zinc	0.05
Silicon, max.	0.05
Copper, max.	0.02
Nickel, max.	0.001
Iron, max.	0.03
Other impurities, max.	0.05 each or 0.3 max. total
Magnesium	remainder

The Contractor shall furnish spectrographic analysis on samples from each heat or batch of anodes used on this project.

2.1.2 Dimensions and Weights

Dimensions and weights of anodes shall be approximately as follows:

TYPICAL MAGNESIUM ANODE SIZE
(Cross sections may be round, square, or D shaped)

Nominal Wt. Lbs.	Approx. Size (In.)	Nominal gross Wt. 1b Packaged In Backfill	Nominal Package Dimensions (In)
3	3 x 3 x 5	8	5-1/4 x 5-1/4 x 8
5	3 x 3 x 8	13	5-1/4 x 5-1/4 x 11-1/4
9	3 x 3 x 14	27	5-1/4 x 20
12	4 x 4 x 12	32	7-1/2 x 18
17	4 x 4 x 17	45	7-1/2 x 24
20	2-1/2 x 2-1/2 x 58	72	5 x 5 x 62
32	5 x 5 x 20-1/2	68	8-1/2 x 28
50	7 x 7 x 16	100	10 x 24

2.1.3 Packaged Anodes

Anodes shall be provided in packaged form with the anode surrounded by specially –prepared quick-wetting backfill and contained in a water permeable cloth or paper sack. Anodes shall be centered by means of spacers in the backfill material. The backfill material shall have the following composition, unless otherwise indicated:

Material	*Approximate Percent by Weight*
Gypsum	75
Bentonite	20
Sodium Sulphate	5
TOTAL	100

2.1.4 Zinc Anodes - Not Used

2.1.5 Connecting Wire

2.1.5.1 Wire Requirements

Wire shall be No. 12 AWG solid copper wire, not less than 10 feet long, unspliced, complying with NFPA 70, Type TW or RHW insulation. Connecting wires for magnesium anodes shall be factory installed with the place or emergence from the anode in a cavity sealed flush with a dielectric sealing compound.

2.1.5.2 Anode Header Cable – Not Used

2.2 MISCELLANEOUS MATERIALS

2.2.1 Electrical Wire

Wire shall be No. 12 AWG stranded copper wire with NFPA 70, Type TW or RHW-USE insulation. Polyethylene insulation shall comply with the requirements of ASTM D 1248 and shall be of the following types, classes, and grades:

2.2.1.1 Wire Splicing

Connecting wire splicing shall be made with copper compression connectors or exothermic welds, following instructions of the manufacturer. Single split-bolt connections shall not be used. **??????????????** cover rubber type with two layers of ½ overlap vinyl tape

2.2.1.2 Test Wires (Structure Connection)

Test wires shall be AWG No. 12 stranded copper wire with NFPA 70, Type TW, RHW or USE insulation.

2.2.1.3 Resistance Wire – Not Used

2.2.2 Conduit – Not Used

2.2.3 Test Boxes and Junctions Boxes

Boxes shall be outdoor type conforming to UL 514A.

2.2.4 Joint, Patch, Seal, and Repair Coating

All underground metal couplings, bolts, and nuts shall be coated with a material that is compatible with the coating of the fire hydrant and valve. There shall be at least two coats of epoxy, 5 mil per coat for a total dry film thickness of 10 mil. Surface preparation should be in accordance with the coating manufacturer's instruction.

2.2.5 Backfill Shields

Shields shall consist of plastic weld caps, specifically made for the purpose and installed in accordance with the manufacturer's recommendations. When joint bonds are required, due to the use of mechanical joints, the entire joint shall be protected by the use of a kraft paper joint cover. The joint cover shall be filled with poured-in, hot coat-tar enamel.

2.2.6 Epoxy Potting Compound – Not Used

2.2.7 Test Stations

Stations shall be of the flush-curb-box type and shall be the standard product of a recognized manufacturer. Test stations shall be complete with an insulated terminal block having the required number of terminals. The test station shall be provided with a lockable cover and shall have an embossed legend, "C.P. Test." A minimum of one (1) test station shall be provided each fire hydrant. A minimum of six (6) terminals shall be provided in each test station. A minimum of two (2) leads are required to the metallic pipe from each test station. Other conductors shall be provided for anodes. The test stations shall be listed for the particular application for which they are to be utilized. C.P. Test services NM series or equal. Metal top of test station shall be painted blue.

2.2.8 Joint and Continuity Bonds

Bonds shall be provided across all joints in the metallic water lines, across any electrically discontinuous connections and all other pipes and structures with other than welded or threaded joints that are included in this cathodic protection system. Unless otherwise specified in the specifications, bonds between structures and across joints in pipe with other than welded or threaded joints shall be No. 6 AWG stranded copper cable with polyethylene insulation. Bonds between structures shall contain sufficient slack for any anticipated movement between structures. Bonds across pipe joints shall contain a minimum of 4 inches of slack to allow for pipe movement and soil stress. Bonds shall be attached by exothermic welding. Exothermic weld areas shall be insulated with coating compound and approved, and witnessed by the Contracting Officer. Continuity bonds shall be installed as necessary to reduce stray current interference. Additional joint bondings shall be accomplished by the Contractor where the necessity is discovered during construction or testing or where the Contracting Officer or designated representative directs that such bonding be done. Joint bonding shall include all associated excavation and backfilling. There shall be a minimum of one (1) continuity bonds between each structure and other than welded or threaded joints. The Contractor shall test for electrical continuity across all joints with other than welded or threaded joints and across all metallic portions or components. The Contractor shall provide bonding as required and as specified above until electrical continuity is achieved. Bonding test data shall be submitted for approval.

2.2.9 Resistance Bonds - Not Used

2.2.10 Stray Current Measurements – Not Used

2.2.11 Electrical Isolation of Structures

As a minimum, isolating flanges or unions shall be provided at the following locations:

a. Connection of new metallic piping or components to existing piping.

Isolation shall be provided at metallic connection of all lines to existing system.

2.2.11.1 Electrically Isolating Pipe Joints

Electrically isolating pipe joints shall be of a type that is in regular factory production.

2.2.11.2 Electrically Conductive Couplings

Electrically conductive couplings shall be of a type that has a published maximum electrical resistance rating given in the manufacturer's literature. Cradles and seals shall be of a type that is in regular factory production made for the purpose of electrically insulating the carrier pipe from the casing and preventing the incursion of water into the annular space.

2.2.11.3 Insulating Joint Testing

A Model 601 Insulation Checker, as manufactured by "Gas Electronics" or an approved equal, shall be used for insulating joint flange electrical testing.

2.2.12 Underground Structure Coating

This coating specification shall take precedence over any other project specification and drawing notes, whether stated or implied. No variance in coating quality shall be allowed by the Contractor or Base Construction Representative without the written consent of the designer. All underground metallic pipelines to be cathodically protected shall be afforded a good quality factory-applied coating. This includes all carbon steel, cast-iron and ductile-iron pipelines or valves. Coatings shall be selected, applied, and inspected in accordance with NACE RP0190 and as specified. If non-metallic pipelines are installed, all metallic fittings on pipe sections shall be coated in accordance with this specification section.

a. Fire hydrant and Valves: Two coats of epoxy, 5 mils per coat, for a total dry film thickness of 10 mil. Damage to coating during transportation and/or installation shall be repaired in accordance with the coating manufacturer's recommendation.

b. Metallic Couplings: All underground metallic couplings used to connect the fire hydrant, valves, and main together should be cleaned and coated with a spray or brushed-on application of epoxy that is compatible with the factory applied coating. Dry film thickness shall be at least 10 mil. Cleaning and coating of the couplings should be accomplished in accordance with the coating manufacturer's recommendation. A copy of the manufacturer's application procedures must be included with submittals.

2.2.12.1 Field Joints

All field joints shall be coated with materials compatible with the pipeline coating compound. The joint coating material shall be applied to an equal thickness as the pipeline coating. Unbonded coatings shall not be used on these buried metallic components. This includes the elimination of all unbonded polymer wraps or tubes. Once the pipeline or vessel is set in the trench, an inspection of the coating shall be conducted. This inspection shall include electrical holiday detection. Any damaged areas of the coating shall be properly repaired. The Contracting Officer shall be asked to witness inspection of the coating and testing using a holiday detector.

2.2.12.2 Inspection of Pipe Coatings

Any damage to the protective covering during transit and handling shall be repaired before

installation. After field coating and wrapping has been applied, the entire pipe shall be inspected by an electric holiday detector with impressed current in accordance with NACE RP0188 using a full-ring, spring-type coil electrode. The holiday detector shall be equipped with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. All holidays in the protective covering shall be repaired immediately upon detection. Occasional checks of holiday detector potential will be made by the Contracting Officer or designated representative to determine suitability of the detector. All labor, materials, and equipment necessary for conducting the inspection shall be furnished by the Contractor.

2.2.13. Resistance Wire

2.2.14 Electrical Connections

Electrical connections shall be done as follows:

a. Exothermic welds shall be "Cadweld", "Bundy" "Thermoweld", or an approved equal. Use of this material shall be in strict accordance with the manufacturer's recommendations.

b. Electrical –shielded arc welds shall be approved for use on steel pipe by shop drawing submittal action.

c. Brazing shall be as specified in Paragraph: Lead Wire Connections.

2.2.15 Electrical Tape

Pressure-sensitive vinyl plastic electrical tape shall conform to UL 510.

2.2.16 Permanent Reference Electrodes – Not Used

2.2.17 Casing – Not Used

PART 3 EXECUTION

3.1 CRITERIA OF PROTECTION

Acceptance criteria for determining the adequacy of protection on a buried underground pipe or metallic component shall be in accordance with NACE RP0169 and as specified below.

3.1.1 Iron and Steel

The following method a. shall be used for testing cathodic protection voltages. If more than one method is required, method b. shall be used.

a. A negative voltage of at least minus 1000 millivolts as measured between the underground component and a saturated copper-copper sulphate reference electrode connecting the earth (electrolyte) directly over the underground component. Determination of this voltage shall be made with the cathodic protection system in operation. Voltage drops shall be considered for valid interpretation of this voltage measurement. A minimum of minus 1000 millivolts potential between the underground component being tested and the reference cell shall be achieved over 95 percent of the area of the structure. Adequate number of measurements

shall be obtained over the entire structure, pipe or other metallic component to verify and record achievement of minus 1000 millivolts. This potential shall be obtained over 95 percent of the total metallic area.

b. A minimum polarization voltage shift of 100 millivolts as measured between the underground component and a saturated copper-copper sulphate reference electrode contacting the earth directly over the underground component. This polarization voltage shift shall be determined by interrupting the protective current and measuring the polarization decay. When the protective current is interrupted, an immediate voltage shift will occur. The voltage reading, after the immediate shift, shall be used as the base reading from which to measure polarization decay. Measurements achieving 100 millivolts decay shall be made over 95 percent of the metallic surface being protected.

c. For any metallic component, a minimum of four (4) measurements shall be made using subparagraph a., above, and achieving the potential of minus 1000 millivolts. Two (2) measurements shall be made over the anodes and two (2) measurements shall be made at different locations near the component and farthest away from the anode.

3.1.2 Aluminum – Not Used

3.1.3 Copper Piping – Not Used

3.2 ANODE STORAGE AND INSTALLATION

3.2.1 Anode Storage

Storage area for magnesium anodes will be designated by the Contracting Officer. If anodes are not stored in a building, tarps or similar protection should be used to protect anodes from inclement weather. Packaged anodes, damaged as a result of improper handling or being exposed to rain, shall be resacked by the Contractor and the required backfill added.

3.2.2 Anode Installation

Unless otherwise authorized, installation shall not proceed without the presence of the Contracting Officer. Anodes of the size specified shall be installed to the depth indicated and at the locations shown. Locations may be changed to clear obstructions with the approval of the Contracting Officer. Anodes shall be installed in sufficient number and of the required type, size, and spacing to obtain a uniform current distribution over the surface of the structure. The anode system shall be designed for a life of 25 years of continuous operation. Anodes shall be installed as indicated in a dray condition after any plastic or water proof protective covering has been completely removed from the water permeable, permanent container housing the anode metal. The anode connecting wire shall not be used for lowering the anode into the hole. The annular space around the anode shall be backfilled with fine earth in 6 inch layers and each layer shall be hand tamped. Care must be exercised not to strike the anode or connecting wire with the tamper. Approximately 5 gallons of water shall be applied to each filled hole after anode backfilling and tamping has been completed to a point about 6 inches above the anode. After the water has been absorbed by the earth, backfilling shall be completed to the ground surface level.

3.2.2.1 Single Anodes

Single anodes, spaced as shown, shall be connected through a test station to the pipeline, allowing adequate slack in the connecting wire to compensate for movement during backfill operation.

3.2.2.2 Groups of Anodes (3 or More)

3.2.2.3 Welding Methods

Connections to ferrous pipe shall be made by exothermic weld methods manufactured for the type of pipe supplied. Electric arc welded connections and other types of welded connections to ferrous pipe and structures shall be approved before use.

3.2.3 Anode Placement – General

Packaged anodes shall be installed completely dry, and shall be lowered into holes by rope sling or by grasping the cloth gather. The anode lead wire shall not be used in lowering the anodes. The hole shall be backfilled with fine soil in 6 inch layers and each layer shall be hand-tamped around the anode. Care must be exercised not to strike the anode or lead wire with the tamper. If immediate testing is to be performed, water shall be added only after backfilling and tamping has been completed to a point 6 inches above the anode. Approximately 5 gallons of water may be poured into the hole. After the water has been absorbed by the soil, backfilling and tamping may be completed to the top of the hole. Anodes shall be installed as specified or shown. In the event a rock strata is encountered prior to achieving specified augured-hole depth, anodes may be installed horizontally to a depth at least as deep as the bottom of the pipe, with the approval of the Contracting Officer.

3.2.4 Underground Pipeline

Anodes shall be installed at a minimum of 3 feet and a maximum of 10 feet from the line to be protected.

3.2.5 Installation Details

Details shall conform to the requirements of this specification. Details shown on the drawings are indicative of the general type of material required, and are not intended to restrict selection to material of any particular manufacturer.

3.2.6 Lead Wire Connections

3.2.6.1 Underground Pipeline (Metallic)

To facilitate periodic electrical measurements during the life of the sacrificial anode system and to reduce the output current of the anodes, if required, all anode lead wires shall be connected to a test station and buried a minimum of 24 inches in depth. The cable shall be as shown on drawings stranded copper, polyethylene of RHW-USE insulated cable. The cable shall make contact with the structure only through a test station. Lead wire-to-structure connections shall be accomplished by an exothermic welding process. All welds shall be in accordance with the manufacturer's recommendations. A backfill shield filled with a pipeline mastic sealant or material compatible with the coating shall be placed over the weld connection and shall be of such diameter as to cover the exposed metal adequately.

3.2.6.2 Resistance Wire Splices – Not Used

3.2.7 Location of Test Stations

Test stations shall be of the type and location shown and shall be curb box mounted. Buried insulating

joints shall be provided with test wire connections brought to a test station. Unless otherwise shown, other test stations shall be located.

Where both sides of an insulating joint are not accessible above ground for testing purposes.

3.2.8 Underground Pipe Joint Bonds

Underground pipe having other than welded or threaded coupling joints shall be made electrically continuous by means of a bonding connection installed across the joint.

3.3 ELECTRICAL ISOLATION OF STRUCTURES

3.3.1 Isolation Joints and Fittings

Isolating fittings, including main line isolating flanges and couplings, shall be installed aboveground, or within manholes, wherever possible. Where isolating joints must be covered with soil, they shall be fitted with a paper joint cover specifically manufactured for covering the particular joint, and the space within the cover filled with hot coal-tar enamel.

3.3.2 Gas Distribution Piping - Not Used

3.4 TRENCHING AND BACKFILLING

Trenching and backfilling shall be in accordance with Section 02300 EARTHWORK.

3.5 TESTS AND MEASUREMENTS

3.5.1 Baseline Potentials

Each test and measurement will be witnessed by the Contracting Officer. The Contractor shall notify the Contracting Officer a minimum of five (5) working days prior to each test. After backfill of the pipe, the static potential-to-soil of the pipe shall be measured. The locations of these measurement s shall be identical to the locations specified for pipe –to-reference electrode potential measurements. The initial measurements shall be recorded. These tests are made before the anodes are connected to the structure. Anode wires shall be connected to structure wires inside test station after completing baseline potential test.

3.5.2 Isolation Testing

Before the anode system is connected to the pipe, an isolation test shall be made at each isolating joint or fitting. This test shall demonstrate that no metallic contact, or short circuit exists between the two isolated sections of the pipe. Any isolating fittings installed and found to be defective shall be reported to the Contracting Officer.

3.5.2.1 Insulation Checker

A Model 601 insulation checker, as manufactured by “Gas Electronics”, or an approved equal, using the continuity check circuit, shall be used for isolating joint (flange) electrical testing. Testing shall conform to the manufacturer’s operation instructions. Test shall be witnessed by the Contracting Officer. An isolating joint that is good will read full scale on the meter. If an isolating joint is shorted, the meter pointer will be deflected or near zero on the meter scale.

Location of the fault shall be determined from the instructions, and the joint shall be repaired. If an isolating joint is located inside a vault, the pipe shall be sleeved with insulator when entering and leaving the vault.

3.5.2.2. Not Used

3.5.3 Anode Output

As the anodes or groups of anodes are connected to the pipe, current output shall be measured with an approved clamp-on milliammeter, calibrated shunt with a suitable millivoltmeter or multimeter, or a low resistance ammeter. (Of the three methods, the low-resistance ammeter is the least desirable and most inaccurate. The clamp-on milliammeter is the most accurate.) the values obtained and the date, time, and location shall be recorded.

3.5.4 Reference Electrode Potential Measurements

Upon completion of the installation and with the entire cathodic protections system in operation for at least 4 weeks, electrode potential measurement shall be made using a copper-copper sulphate reference electrode and a potentiometer-[voltmeter, or a direct-current voltmeter having an internal resistance (sensitivity) of not less than 10 megohms per volt and a full scale of 10 volts. The locations of these measurements shall be identical to the locations used for baseline potentials. The values obtained and the date, time, and locations of measurements shall be recorded. No less than four (4) measurements shall be made over any length of line or component. Current output of the anode or anodes shall be measured and recorded.

3.5.5 Location of Measurements

3.5.5.1 Piping or Conduit

For coated piping or conduit, measurements shall be taken from the reference electrode located in contact with the earth, directly over the pipe. Connection to the pipe shall be made at test leads, or by other means suitable for test purposes. Pipe-to-soil potential measurements shall be made at intervals not exceeding 5 feet. Locations where potentials do not meet or exceed the criteria shall be identified and reported to the Contracting Officer or designated representative.

3.5.5.2 Tanks – Not Used

3.5.5.3 Casing Test – Not Used

3.5.5.4 Interference Testing – Not Used

3.5.5.5 Holiday Test

Any damage to the protective covering during transit and handling shall be repaired before installation. After field-coating and wrapping has been applied, the entire pipe shall be inspected by an electric holiday detector with impressed current in accordance with NACE RP0188using a full-ring, spring-type coil electrode. The holiday detector shall be equipped with a bell, buzzer, or other type of audible signal which sounds when a holiday is detected. Holidays in the protective covering shall be repaired upon detection. Occasional checks of holiday detector potential will be made by the Contracting Officer to determine suitability of the detector. Labor, materials, and equipment necessary for conducting the inspection shall be furnished by the Contractor. The

coating system shall be inspected for holes, voids, cracks, and other damage during installation.

3.5.5.6 Recording Measurements

All pipe –to-soil potential measurements, including initial potentials where required, shall be recorded. The Contractor shall locate, correct and report to the Contracting Officer any short circuits to foreign pipes encountered during checkout of the installed cathodic protection system. Pipe-to-soil potential measurements shall be taken on as many pipes as necessary to determine the extent of protection or to locate short-circuits. Current flow measurements must be made at the time of the final potential measurements.

3.6 TRAINING COURSE

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 4 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The field instructions shall cover all of the items contained in the operating and maintenance instructions, as well as demonstrations of routine maintenance operations, including testing procedures included in the maintenance instructions. At least 14 days prior to date of proposed conduction of the training course, the training course curriculum shall be submitted for approval, along with the proposed training date. Training shall consist of demonstration of test equipment, providing forms for test data and the tolerances which indicate that the system works.

3.7 CLEANUP

The Contractor shall be responsible for cleanup of the construction site. All paper bags, wire clippings, etc., shall be disposed of as directed. Paper bags, wire clippings, and other waste shall not be put in bell holes or anodes excavation.

3.8 MISCELLANEOUS INSTALLATION AND TESTING

3.8.1 Coatings

All aboveground pipeline shall be coated as indicated or as approved. The pipeline coating shall be in accordance with all applicable Federal, State, and local regulations.

3.8.2 Excavation

In the event rock is encountered in providing the required depth for anodes, the Contractor shall determine an alternate approved location and, if the depth is still not provided, an alternate plan shall be submitted to the Contracting Officer. Alternate techniques and depths must be approved prior to implementation.

3.9 SPARE PARTS

After approval of shop drawings, and not later than three (3) months prior to the date of beneficial occupancy, the Contractor shall furnish spare parts data for each different item of material and equipment specified. The data shall include a complete list of parts, special tools, and supplies, with current unit prices and source of supply. In addition, the Contractor shall supply information for material and equipment replacement for all other components of the complete system, including anodes, cables, splice kits and connectors, corrosion test stations, and any other components not listed above. The Contractor shall furnish a reference cell on a reel with 350 feet of conductor, along with other accessories, and a digital voltmeter that can be used in the maintenance of this cathodic protection system. Use of this equipment shall include a description of the equipment and measurement of the pip-to-soil potential.

3.10 SEEDING

Seeding shall be done by the Contractor, as directed, in all unsurfaced locations disturbed by this construction. In areas where grass cover exists, it is possible that sod can be carefully removed, watered, and stored during construction operations, and replaced after the operations are completed since it is estimated that no section of pipeline should remain uncovered for more than two (2) days. The use of sod in lieu of seeding shall require approval by the Contracting Officer.

3.11 SYSTEM TESTING

The Contractor shall submit a report including baseline potential measurements, final potential measurement s and current measurements taken at adequate intervals to establish that minus 1000 millivolts potential, is provided. The report shall provide a narrative describing how the criteria of protection is achieved.

3.12 CLEARIGN OF TREES AND UNDERBRUSH - Not Used

END OF SECTION